Critical Design Considerations For Adsorptive Media For Arsenic Removal

Eric Winchester, Vice President

ADI International Inc.

Critical Design Considerations

- Process Design
- Sizing of Adsorber Vessels
- Secondary Process Considerations

Design Input Data

- Chemical analysis of the water.
- Treated water compliance standard.
- Regulatory design standards.
- Residuals disposal.
- Design flow rates and consumption.

Design Input Data

Chemical Analysis

- Arsenic and pH: adsorption capacity increases with As conc. And decreases with high pH.
- Certain elements may interfer with adsorption capacity - silica, iron, sulfate, chloride.
- Other metals are adsorbed also.

Design Input Data

Compliance & Design Standards

- EPA MCL - 10 ppb
- Other Agencies: 3 to 10 ppb

- Min / Max operating parameters, e.g., gpm / sf
- NSF Standard 61
- EPA / NSF ETV Program
- Other, e.g., ASME code

Design Input Data
Residuals

- Initial media conditioning - backwash, rinse, disinfection.
- Normal backwash and rinse during use.
- Regeneration chemicals.
- Spent media.

Design Input Data

Flow Rates & Consumption

- Well pump capacity used to hydraulically design system - physical size of filters, piping, chemical feed.

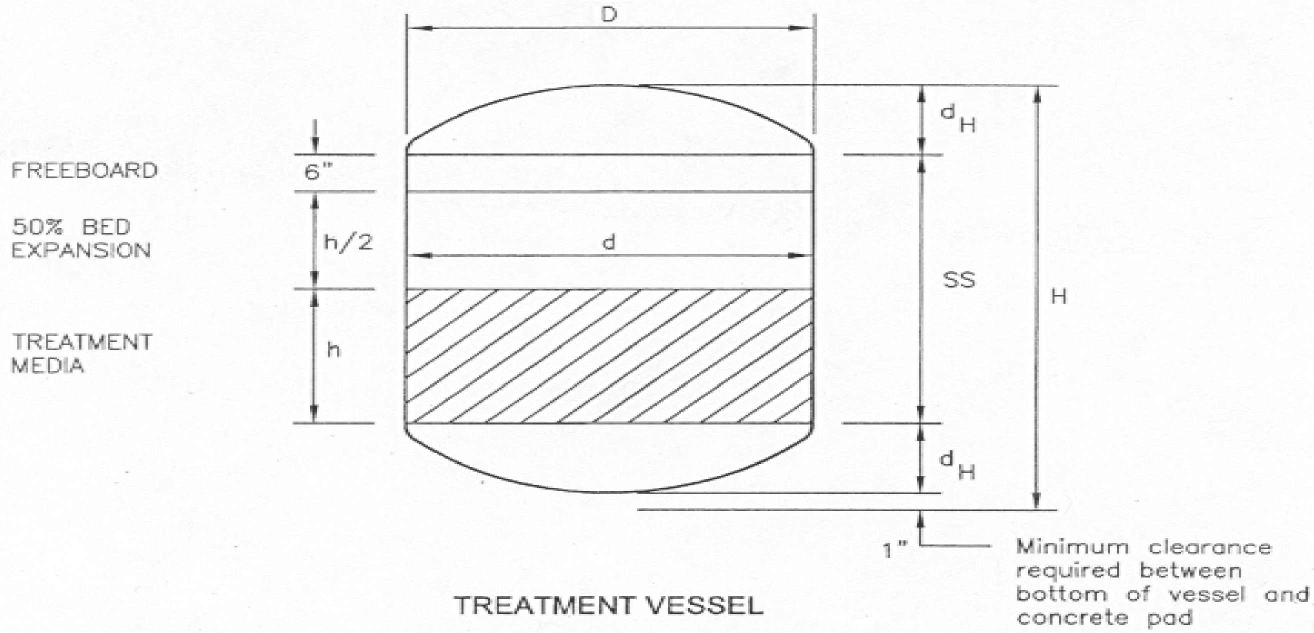
- Consumption used to estimate media life and operating cost.

Design Options

- Selection of adsorptive media.
- With or without pH adjustment.
- Spent media regeneration, or one-time use & disposal.
- Series or parallel operation.
- Manual or automatic control.

Design and Cost Considerations

- Empty Bed Contact Time (EBCT).
- Series or parallel operation.
- pH adjustment.
- Regeneration capability.
- Oxidation - As III to As V.



SYMBOLS

q – TREATED WATER FLOW RATE (gpm)

d – TREATMENT BED DIAMETER (ft.), $d = \sqrt{4V/\pi h}$

h – TREATMENT BED DEPTH (ft.)

V – TREATMENT BED VOLUME – $\frac{\pi d^2 h}{4}$ (ft.^{3})

M_d – DENSITY OF TREATMENT MEDIA (lb./ft.^{3})

M_w – WEIGHT OF MEDIA (lbs.)

D – OUTSIDE DIAMETER OF TREATMENT VESSEL (ft.)

d_H – DEPTH OF DISHED PRESSURE HEAD (ft.)

H – OVERALL HEIGHT OF SKID MOUNTED TREATMENT VESSEL (ft.)

SS – STRAIGHT SIDE (ft.)

GIVEN

$d > h/2$, $3'\text{-}0" < h < 6'\text{-}0"$

$H = 2\,d_H + h + h/2 + 6" + 1"$

$D = d + 1"$

$M_d = 45$ lb./ft^3 (VARIES WITH MEDIA IN VESSEL)

$M_w = M_d \times V = 45V$ (lb.)

Figure 3-5. Treatment Bed and Vessel Design Calculations

Design & Cost Considerations

EBCT

- Range - 3 to 10 minutes
- Activated alumina - 5 min +
- ADI's MEDIA G2 uses 8 to 10 min, results in a unit flow rate of 2.5 to 3 gpm/sf
- The lower the EBCT, the higher the unit flow rate.

Design & Cost Considerations

EBCT & Bed Volumes

- The lower the EBCT, the smaller the size of vessels.
- Adsorption capacity determines the no. of bed volumes or the quantity of water treated in gallons before arsenic break-through.

Design & Cost Considerations

Bed Volumes

- Why not use a longer EBCT and larger bed volume to increase the total amount of treated water before break-through?
- Initial cost may be a factor.
- Ask whether lower service flow rates (gpm/sf) can be tolerated.
- Ask whether there are any minimum flow limitations under NSF 61 standard, i.e., gpm/cf of media or a max use level.
- There is a diminishing return on increasing EBCT related to performance and adsorption capacity.

Design & Cost Considerations

Series or Parallel

- Advantage of series:

- Redundancy and safety.
- Maximum use of media capacity.
- More flexible for scheduling of media change-outs.

Design & Cost Considerations

Series or Parallel

- Disadvantages of series:

- Increased capital cost due to number and size of filters.
- Larger foot print.
- Higher pressure drop.
- Need for larger backwash rates.

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Design & Cost Considerations

pH Adjustment

- Disadvantages:
- Increased complexity of operation.
- Trained operators needed to address handling & safety issues.
- Loss of pH control may cause arsenic desorption of some media (ask the vender for details).

Design & Cost Considerations

pH Adjustment

- **Advantages:**
- **In many cases, results in lower As concentration in treated water.**
- **Increased adsorption capacity & hence longer media life.**
- **Same pH chemicals are then available for media regeneration.**

Design & Cost Considerations

Regeneration

- Disadvantages:

- Increased complexity.
- Another waste stream for disposal.
- May not be economical for non-pH adjusted water.

Design & Cost Considerations

Regeneration

- Advantages:

- Substantial increase in media life (Not all media can regenerated).
- Less frequent media change-outs.
- Lower operating cost.

Design & Cost Considerations

Oxidation - As III to As V

- Chlorine used for disinfection will oxidize As III to As V for easier removal and longer bed life.

- For some media, exposure to chlorine will degrade performance, e.g., activayed alumina.

Sizing of Adsorber Vessels

- Empty Bed Contact Time (EBCT).
- Media bed depth.
- Bed expansion.
- Unit flow rate.
- Parallel or series operation.

Secondary Process Considerations

- Need for pH feed-back control and alarms when pH corrected.
- Re-adjust pH after treatment ?
- Manual vs automatic control.
- Filter internals – no different than conventional multi-media filters.
- Pre-treatment.

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www.adi.ca